COVER WITH RECLOSEABLE APERTURE

BACKGROUND ART

[0001] The present invention relates to a cover for sealing a container.

[0002] The volume of liquids used for chemical analysis is often very small and in the range of a few microliters. To protect such liquid against evaporation, it is necessary to cover the container in which the liquid is placed with a cap or similar means. The cap is preferably airtight.

[0003] In an example a well plate having a plurality of containers, each container containing a liquid to by analyzed, is covered and made airtight by a cover and preferable a foil. The cover might be glued or welded onto the well plate after the containers are filled with liquid. The cover or foil respectively, comprises aluminum for example. If the liquid in a container of such a well plate is to be analyzed a pipette or a glass capillary will hole through the cover and retrieve the liquid.

[0004] However, the holing procedure might damage the glass capillary or even contaminate the liquid. The liquid in the container itself will start to evaporate due to the remaining hole.

DISCLOSURE OF THE INVENTION

[0005] It is an object of the present invention to provide improved sealing means for a container. This object is solved by the independent claim. Other embodiments of the invention are subject of further dependent claims.

[0006] For chemical analysis the substance to be analyzed is often dissolved within a solvent and the filled into a container. Sometime liquid itself is the substance to be analyzed. The container however, in which the solvent or the liquid is filled before further processing, comprises only a small volume in the range of few milliliter down to sub-microliters. It is therefore necessary that any evaporation of the liquid is kept as small as possible. Any direct connection with open air should be prevented.

[0007] An improved sealing is achieved by a cover for sealing a container or a

vessel comprising a first layer called a bottom layer and a second layer called a top layer which is arranged over the first layer. The first and the second layer are structured in a way to form a recloseable aperture. The recloseable aperture will prevent any evaporation of the liquid and further provide an easy access for a pipette or a glass capillary if need arise. Using a recloseable aperture will prevent damaging any pipette or contamination of the liquid. As soon as the liquid is retrieved and the glass capillary or pipette removed from the container the aperture will close again. Using at least two layers arranged over each other allows a better airproof performance. Preferable the cover for sealing a liquid is formed as a foil, while the top and bottom layers are two different foil layers.

[0008] In a first embodiment of the invention at least one of those layers comprises a flap. In a second embodiment of the invention at least one of those two layers comprises a butterfly valve. The baffle as well as the butterfly valve is able to seal the aperture hermetically, thus preventing any liquid from evaporation.

[0009] In a further embodiment of the invention at least one of said first layer and said second layer comprises a shutter, a baffle or a damper. Preferable the top and the bottom layer each comprise a baffle, butterfly valve, damper, shutter or flap or any other means and structure respectively, that will allow them to form a recloseable aperture through the cover. In another embodiment the top and bottom foil layer comprise a flap, shutter, or butterfly valve.

[00010] In an embodiment of the invention at least one of the top or bottom layer is structured with a U-shaped cut through the layer, thus forming the baffle, butterfly valve, clapper, shutter or flap. Forming the flap or the butterfly valve by using a U-shaped cut in at least on of the first and second layer production costs are reduced and the material used for the top or bottom layer can be used for the baffle of the butterfly valve as well.

[00011] The baffle, butterfly valve, shutter, damper, or flap each comprises a bending axis. The shutter, flap, damper, baffle or butterfly valve bends along that axis. In one embodiment of the invention the bending axis is mainly parallel along the connection of the baffle, butterfly valve, shutter or flap with the remaining layer material. In such case

the bending axis is formed as a bending fold or a snap-off fold respectively. In case of a U-shaped cut in the respective layer, the bending axis is formed between the edges of the parallel sides of the U-shaped cut.

[00012] In a further embodiment the snap-off fold or bending axis of said baffle or butterfly valve, shutter, flap or clapper of the first layer is not arranged over a bending axis or snap-off fold of the baffle, butterfly valve, shutter, flap or clapper of the second layer. Such an arrangement will improve the closing behavior of the recloseable aperture. Furthermore the sealing effect by the two layers against air is improved.

[00013] In a further embodiment of the invention at least one of the first and second layers comprises a cross-shaped cut. The cross-shaped cut is forming a recloseable valve, having four parts. Each part of the recloseable valve comprises a rotational axis. In a further embodiment the first and the second layer comprise a cross-shaped cut wherein the cross-shaped cut of the second foil layer is arranged with an offset of approximately 45° to the cross-shaped cut of the first layer. In another embodiment of the invention the top layer comprises a diaphragm-like recloseable aperture.

[00014] The different structure of the top and the bottom layer are forming recloseable apertures themselves. However small amounts of air can flow through the cut forming the structures. Due to the arrangement of at least the top layer on to the second layer, the probability of air flowing through both cuts is significantly reduced. Such arrangement is considered airtight against evaporation of a liquid in a container arranged below the recloseable aperture. The different apertures of the top and the bottom layer can be arranged in any combination.

[00015] In an embodiment of the invention the top and bottom layer are glued together by polymerization in the area around the recloseable aperture. In another embodiment of the invention the top layer is laminated at least partly onto the second layer, thereby forming a strong and airtight connection. Preferable the top and bottom layers are foil layers in this embodiment of the invention.

[00016] In a further embodiment of the invention the cover comprises a moveable third layer arranged between the top and bottom layer. The moveable third layer is

used for closing an aperture in the first and second layer. In an embodiment of the invention the movable third layer is formed as a movable foil layer between the first and second layer. In this embodiment the third layer arranged between the top and bottom layer is structured to form a sliding valve. Using a third layer or a third foil layer in between the top and bottom layer structured as a sliding valve allows an easy way to open the aperture, for example when inserting a pipette and closing the aperture in the cover to prevent any liquid from evaporation. Such embodiment allows access to the liquid directly without contacting the cover, thereby preventing any contamination of the liquid through picking of material on the cover's surface.

[00017] In an embodiment of the invention the cover comprises means for moving the third layer for closing the aperture. Such means can be formed as an anchor, hook or the like. In another embodiment of the invention the cover comprises a seal material arranged at least between the third moveable layer and the bottom layer in the area of the recloseable aperture. The seal will prevent an air connection between the third moveable layer and the bottom layer. The seal, for example comprises Teflon, Silicon, PTFE (Poly-Tetra-Fluor-Etylene) or any other polyimide and is preferably structures as a ring around the aperture's area. Other materials for the seal can also be used.

[00018] In yet another embodiment of the invention the recloseable aperture is ring-shaped, or elliptical. In a further embodiment the recloseable aperture is formed as an approximately rectangular recloseable aperture.

[00019] At least one layer comprises a polyamide, polyimid, or polyester material. It can also comprise any other polymer compound including liquid crystal polymer compounds. In a further embodiment the top layer comprises an electrically conductive coating layer. For example the top layer might comprise aluminum. The cover itself can have a thickness smaller than 400 µm. Preferably each layer of the cover comprises a thickness of about 40 to 100 µm. In an embodiment of the invention the recloseable aperture of the cover comprises an area smaller than 60 mm2. More specifically a diameter of the cover's aperture can about the same size as a diameter the pipette or glass capillary when inserted into the container to take in some liquid.

[00020] In a further embodiment of the invention the cover comprises a plurality of

recloseable apertures. Such cover is used for sealing a well plate, a micro well plate or a micro plate. The well plate comprises a plurality of liquid containers. The arrangement of a cover according to the invention on top of a well plate allows sealing its containers airtight while still having the possibility of easy access to the liquid within the containers. The cover is not damaged during liquid retrieving. The different forms of recloseable apertures in the first, second and third layer can be combined independently from each other. They can be adopted as foil layer arranged on top of and connected to each other. Higher protection against evaporation of the liquid in the container can be achieved by arranging additional layers with a recloseable aperture between or onto the first or second layer.

BRIEF DESCRIPTION OF DRAWINGS

[00021] Other objects and many of the attendant advantages of embodiments of the present invention will be readily appreciated and become better understood by reference to the following more detailed description of preferred embodiments in connection with the accompanied drawings. All figures are simplified schematic representations presented for illustrations purposes only and do not limit the invention or the scope of protection. Features that are substantially or functionally equal or similar will be referred to with the same reference sign(s).

[00022] Fig. 1 shows a schematic top view of a first embodiment of the invention.

[00023] Fig. 2 shows a schematic view through the I-II-plane of Figure 1.

[00024] Fig. 3A to Figure 7B show the top views as well as side views through the I-II-plane of different embodiments of the invention.

[00025] Fig. 8 shows different recloseable apertures together with their bending axes.

[00026] Fig. 9 shows a schematic "explosion" view of a further embodiment of the invention.

[00027] Fig. 10 shows the top view of a sealing cover for a well plate.

[00028] Fig. 11A shows another top view of a three-layer sealing cover used to seal a well plate comprising a plurality of containers.

DETAILED DESCRIPTION OF THE EMBODIMENT OF THE INVENTION

[00029] Referring now to Figure 1 and figure 2, which show a top and a side view along the I-II plane of a cover 4 according to a first embodiment of the present invention. The cover is formed as a foil 4. The foil covers a container 1 for a liquid and is connected to that container. The container 1 is part of a well plate not shown here. The container 1 is formed as a cone with a radius R on its upper side, which is indicated in figure 1 as a ring. The radius R of the container 1 is bigger than any dimension of the recloseable opening of the foil 3. Opening the cover 4 or foil respectively will allow access to a liquid placed in the container 1.

[00030] The foil 4 comprises a top foil layer 2. The top foil layer 2 comprises a recloseable aperture 24 arranged directly over a second recloseable aperture 34 of a bottom foil layer 3. Both recloseable apertures 24 and 34 are structures as flaps.

[00031] The aperture 24 is formed by two parallel cuts 21 in the foil layer 2 and a slightly U-shaped cut mainly perpendicular to both cuts 21. Furthermore the recloseable aperture 24 of the top foil layer 2 comprises a bending axis 25. The foil layer material forming the aperture 24 will bend along the line 25 when pushed down or pulled up. The bending axis 25 as indicated by the dashed line is also slightly U-shaped in order to create tension when pushed down. The bending fold axis 25 will be formed automatically, if three sides are cut. However in this embodiment the top foil layer is slightly slit along the line 25 in order to form a preferred bending axis. The tension will automatically reclose the aperture after the top foil layer 2 in the area 24 is pushed down and released. The cuts in the foil layer are produced by a laser induced cutting process, resulting in very small gaps between the foil layer in area 24 and the surrounding foil layer. However instead of laser induced cutting, different method like micro stamping or other alternatives can be used. The cuts produced by those methods are too small to allow greater amounts of air flowing through those gaps.

[00032] The top layer 2 is bonded onto a bottom layer 3. The bottom layer 3 also

comprises a recloseable aperture 34, which comprises a bigger area than the recloseable aperture 24 of top layer 2. The recloseable aperture 34 is formed by two parallel cuts 31 along and a further slightly U-shaped cut 33. The cuts 31 are approximately parallel to the cuts 21 forming the recloseable aperture 24 or flap 24 of top foil layer 2.

[00033] The fourth side 35 of the recloseable aperture 34 is forming a bending axis or bending fold 35 as indicated by the dashed line. The cuts 31 and 33 are very small. Furthermore, the top layer 2 with the recloseable aperture 24 is bonded directly on the bottom layer 3. The area 24 is connected directly to the area 34 resulting in a very small or even no volume 5A between the recloseable apertures of both foil layers. The cuts 21, 22 as well as 31, 33 of top layer 2 and bottom layer 3 are formed on different areas. Any air flowing through one of those cuts has to move along the very small area 5A in between the two recloseable apertures and then through one of the cuts of the other foil layer. The likelihood of such airflow is very small. Therefore, the arrangement of top layer 2 onto bottom layer 3 each with a recloseable aperture will significantly reduce or even prevent any airflow from outside into container 1. Evaporation of a liquid within container 1 will be prevented.

[00034] To gain access to the container 1 the recloseable aperture of the foil must be opened. This can be achieved by pushing onto the areas 24 and 34 thereby opening each flap in the foil layers 2 and 3. Pushing down movable foil layers 24 and 34 will reduce the pressure exerted by the pipette or a glass capillary. Damage to the pipette will be prevented. Due to the arrangement of the bending axes 25 and 35 on opposite sides, the foil layers in the area 24 and 34 open in different directions. The flap 24 of foil layer 2 opens in a clock-wise direction while the recloseable aperture 34 of bottom layer 3 opens counter-clockwise. This structure will further improve the sealing effect.

[00035] Referring now to Figure 3A and Figure 3B. Figure 3A shows a top view of another embodiment of the invention. The top layer 2 is a foil layer and comprises two cuts 21 and 22. The cuts 21 and 22 are arranged with an offset of 90° and forming a cross-shaped cut in the top layer 2. Together with their bending folds 25 the cuts 21 and 22 are forming four virtual triangles structures as flaps or butterfly valves for top

layer 2. The top layer 2 also comprises a top layer coating 2A. The top layer coating 2A is made of a metal, for example aluminum. It covers the area of the butterfly valve. The metal coating 2A allows a better positioning of a pipette or a glass capillary in an attempt for withdrawing liquid from a container. The positioning of a pipette is described in application EP 04 000 688.4, which is incorporated herein by, reference.

[00036] The top layer 2 is connected by a lamination layer 6 to a bottom layer 3. The bottom layer 3 if formed as a foil layer as well and comprises two cuts 31 and 33, forming a cross-shaped cut and thereby structures as butterfly valves as well. The intersection of the cuts 31 and 33 are arranged under the intersection of the cuts 21 and 22 of top foil layer 2. Furthermore, the cross-shaped cuts of both foil layers 2 and 3 are arranged with an offset of approximately 45°.

[00037] Referring now to Figure 4A and Figure 4B. The top layer 2 and the bottom layer 2 are connected together by polymerization to form the cover. During the fabrication process the top layer 2 as well as the bottom layer 3 are not polymerized completely. After processing of each layer, the recloseable apertures in each layer are formed. Then the top layer 2 is arranged over the bottom layer 3. After the arrangement the process for the remaining polymerization procedure is performed. The polymerization process will connect at a top layer 2 to the bottom layer 3, leaving the area of the recloseable apertures of top and bottom layers unconnected.

[00038] The top layer 2 comprises a diaphragm-like cut 41 having in this example five curved cuts. Each cut is curved in a spiral like manner with an increasing radius starting from the center point 42. The resulting structure covers an area slightly bigger than the area of the recloseable aperture of bottom layer 3. Bottom layer 3 comprises a recloseable aperture 34 with a parabolic formed cut. The center point 42 is arranged over the focal point of the parabolic recloseable aperture 34 of bottom layer 3. Of course it can be arranged anywhere over the aperture 34.

[00039] Referring now to Figure 5A and 5B. The cover of figure 5A comprises three foil layers 2, 3 and 8. The top foil layer 2 is laminated to the middle foil layer 8 by a lamination process. The foil layer 8 is laminated to the bottom foil layer 3. The lamination layers 6 and 6A are small compared to the foil layers 2, 3 and 8.

[00040] Top foil layer 2 of the foil according to the embodiment of figure 5A comprises three cuts thereby forming a star. The center point 41 is arranged over a recloseable aperture 84 of middle foil layer 8. The aperture 84 of the third foil layer 8 is formed as a flap with a bending fold axis 85 arranged directly over a cut 31 forming a recloseable aperture 34 of the bottom foil layer 3. The bending axis 85 of the recloseable aperture 84 and the bending fold axis 35 of the aperture 34 are indicated by dashed lines. They are shifted by an offset of 90°. The area of the recloseable aperture 34 is slightly bigger than the area of the recloseable aperture 85, which is also smaller than the area of the recloseable aperture of top foil layer 2.

[00041] When retrieving a liquid from a container arranged below the recloseable aperture of the inventive foil by a pipette or a glass capillary, one has simply to push the pipette through the recloseable apertures of foil layer 2, 8 and 3. After removal of the pipette the apertures of layers 3, 8, 2 are closing again thereby preventing any evaporation of the remaining liquid in the container.

[00042] Referring now to Figure 6A and Figure 6B. Figures 6A and 6B show another preferred embodiment of the present invention. The cover comprises a top layer 2. The top layer 2 comprises a circular hole 27. A diameter of the hole is about the maximum diameter of a pipette or a glass capillary used for retrieving the liquid. The cover further comprises a bottom layer 3 also having a circular hole 37. The hole 37 is arranged directly under the hole 27 of the top layer 2. Between the top layer 2 and the bottom layer 3 a foil layer 9 is arranged. This third layer 9 is moveable and can be pulled along the direction of the I-II-plane. The third foil layer 9 comprises a hole 94. By pulling the foil layer 9 using an anchor 92 the hole 94 can be arranged directly over the aperture 37 of bottom layer 3. Thereby the middle foil layer 9 provides a sliding valve opening any container arranged below the aperture 37 of the bottom foil layer 3.

[00043] Since the foil layer 9 is moveable between the top layer 2 and the bottom layer 3 small amounts of air might flow into a small volume between the layer 9 and the bottom layer 3. In order to prevent evaporation of liquid out of the container seals 7 are provided. The seals 7 are preferable comprise Teflon or Silicon and adopted to form a ring around the aperture 37. The seals 7 are airtight and connected to the surface of

bottom layer 3. They might comprise a microstructure onto their surfaces resulting in an even better sealing behavior. The seals 7 will prevent any air in the small area between the foil layer 9 and bottom layer 3 from flowing into the container, while pulling or pushing the foil layer 9 arranged between top layer 2 and bottom layer 3.

[00044] Referring now to Figure 7A and Figure 7B. Figure 7 shows another embodiment of the present invention. The cover in this embodiment of the invention comprises a top layer 2, a bottom layer 3 and a foil layer 9 arranged between the top and bottom layer. The top layer 2 comprises an ellipsoid aperture 27. The foil layer 9 comprises a hook 92 for connecting the layer 9 to an outside system in order to pull or push the foil layer 9. It further comprises a circle aperture 94. By moving the foil layer 9 the aperture 94 is arranged under the aperture 27 of top layer 2. The bottom layer 3 comprises a recloseable aperture 34. The recloseable aperture is formed as a flap or shutter with its bending fold axis 35 arranged under the opening 27 of top layer 2. Furthermore seals 7 between the top layer 2 and the middle layer 9 and the middle layer 2 and bottom layer 3 are provided. Evaporation of liquid within a container into the volumes between the top layer 2 and the middle layer 9 or the bottom layer 3 and the middle layer 9 respectively are thereby prevented. Protection against evaporation is improved due to the recloseable aperture 34 of bottom layer 3 and the moveable foil layer 9.

[00045] A further improvement is to implement a recloseable aperture into the movable, middle layer 9. In order to get access to a container arranged under the recloseable aperture of the inventive cover the middle movable layer 9 is moved until its recloseable aperture is arranged under the aperture 27 of top layer 2. The pipette or similar means to open the recloseable aperture of the inventive cover is used to push down the apertures of layers 9 and 3. After processing the liquid the pipette is removed closing the container again.

[00046] Referring now to Figure 8. Figure 8 shows different embodiments of recloseable apertures of a foil layer. The dashed lines indicate the bending axes of the recloseable apertures. The continuous lines are cuts in the foil layer material. The cuts 35 are forming a butterfly valve, while all other examples are forming shutters, baffles

or simple flaps. The foil layer materials used to structure recloseable apertures is firm or rigid respectively to assure a reclosing after the aperture is opened by pushing or pulling the foil layer material.

[00047] Different layers with different recloseable apertures can be arranged in order to form a cover with a recloseable aperture according to the scope of the invention. The different layers can be made of the same material, for example polyamide or polyester or any other organic materials. Polyimide material can also be used. The layers can also comprise a coating layer, for example a metal alloy or an additional seal layer. For example it might be useful to use Silicon as a coating layer on the top and bottom layer in order to reclose the cuts forming the recloseable apertures. The areas of the recloseable apertures for each layer can be of different size. For example the area of the recloseable aperture of the top layer can be smaller than the area of the bottom layer. However it must be as big as the maximum diameter of the pipette or a glass capillary means, which is used to retrieve the liquid from the underlying container. It is also useful if the diameter of the recloseable aperture of the cover according to the invention is smaller than the maximum diameter of the container to be sealed.

[00048] Referring now to Figure 9. Figure 9 shows a schematic explosion view of an inventive cover with different foil layers for a well plate having a plurality of containers. The bottom view of such a cover can be seen in Figure 10. The cover according to the invention of Figure 9 comprises a top foil layer 2. The top foil layer 2 is arranged over a moveable foil layer 9. The layer 9 comprises an anchor 92 and holes 95. The anchor is used to pull or push the layer 9 along the z-axis indicated in figure 9. Additionally layer 2 and movable layer 9 are structured in a way to reduce sliding friction between them. The sliding friction is increased if areas of direct contact between layer 2 and layer 9 are big. The effect is further increased if water molecules are settled in the space between movable layer 9 and layer 2. To reduce areas of direct contact, both surfaces of layer 9 and 2 are nanostructured. This can be achieved by etching both layers. The surface of both layers becomes rough on microscopic scale, resulting in smaller areas of direct contact. Additionally the surface of layer 2 is reduced by structuring the layer differently compared to movable layer 9. For example additional holes are inserted.

[00049] Furthermore a seal 10 is arranged between the moveable foil layer 9 and a third foil layer 3A. Finally a fourth foil layer 3B with recloseable apertures 35 is arranged under the apertures of foil layer 3A. The recloseable apertures 35 of foil layer 3A are structured in a diaphragm like manner as it can also be seen in figure 4.

[00050] The cover or foil respectively according to this embodiment can be used to seal a well plate having a plurality of containers for liquids. Before filling the containers with liquids the cover or foil is glued or welded onto the well plate, thereby sealing the containers and preventing the liquids from evaporation. Furthermore the cover might be welded to the plate between the different containers of the plate, thereby preventing liquid exchange between the containers. For filling and retrieving any liquids from one of the containers the moveable foil 9 is pushed or pulled until its apertures 95 are arranged under the apertures 25 of the top layer 2 and above the apertures 35A of the layer 3A. However, the recloseable aperture 35 of bottom layer 3B will still prevent any evaporation of liquids in containers not needed.

[00051] Referring now to Figure 11. Figure 11 shows a top view of a foil according to one embodiment of the invention used for sealing a well plate W with a plurality of containers W1.

[00052] The foil comprises a foil layer having a plurality of butterfly valves. The recloseable apertures of the inventive foil are arranged above the containers W1 of well plate W. The foil is then connected to the well plate W.